AppKit:

Using the LTC1298 12-bit Analog-to-Digital Converter

This AppKit shows how to use the Linear Technology LTC 1298 12-bit ADC chip with PIC microcontrollers and the Parallax BASIC Stamp® single-board computer.

Description

The LTC1298 is a 12-bit analog-to-digital converter (ADC). It is internally referenced to the 5-volt power supply, providing voltage measurements with 1.22-millivolt resolution. It has an internal sample-and-hold feature that prevents errors when it is used to measure rapidly changing signals.

The LTC1298 can be configured as a two-channel ADC or single-channel differential ADC. In two-channel mode, the selected channel's voltage is measured relative to ground and returned as a value between 0 and 4095. In differential mode, the voltage difference between the two inputs is measured and returned as a value between 0 and 4095.

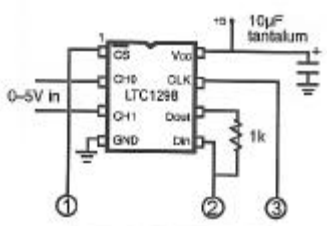
Supply current is typically 250 A when the unit is operating, 1 nA (one -billionth of an ampere) when it is not. The maximum clock rate for the LTC1298's three-wire serial interface is 200 kHz, permitting up to 11,100 samples to be taken per second.

Hardware interface

The LTC1298 interfaces with controllers through four pins: chip select (CS), clock (CLK), data in (DIN) and data out (DOUT). Since PICs can readily switch between input and output on the fly, the interface shown in the figure combines DIN and DOUT into a single connection.

As shown in the figure, the manufacturer recommends a 1- to 10-µF bypass capacitor with good high-frequency qualities; a ceramic unit at the low end of the scale, tantalum at the higher end. Since the supply voltage also serves as the ADC's voltage reference, it must be well regulated to avoid measurement errors. Since the LTC1298 draws very little current, you may use a precision voltage reference Zener diode (such as the LM336) as a regulator.

See the manufacturer's documentation at the end of this App Kit for pcb design notes and analog characteristics.



	PIC	Stamp
1	ra.0	pin 0
2	ra.2	pin 2
3	ra.1	pin 1

Software Interface

From a software standpoint, using the LTC1293 boils down to this:

(1) Activate CS by taking it low.
(2) Send (shift out) configuration bits to the LTC1298.
(3) Read (shift in) the 12-bit measurement from the LTC1298.
(4) Deactivate CS by taking it high.

The program listings and data sheets show these processes in detail.

PIC Program Listing

```
; PROGRAM: LTC1298.SRC (Read LTC1298 analog-to-digital converter).
; Program demonstrates the use of an external serial ADC (Linear Tech
; LTC1298) with PIC16C5x-series controllers. Variable dc voltages
; (0-5V) at pins 2 or 3 of the ADC control the 12-bit value of the
; variable ADres.

CS          =       ra.0            ; Connect to CS pin of 1298.
CLK         =       ra.1            ; Connect to CLK pin.
DATA        =       ra.2            ; Connect to Din and Dout pins.

; Put variable storage above special-purpose registers.
            org     8
Clocks      ds      1               ; Clock-cycle counter.
ADresH      ds      1               ; High byte of 12-bit ADC result.
ADresL      ds      1               ; Low byte of 12-bit ADC result.
Cnfig       ds      1               ; Holds configuration bits for ADC.

Startb      =       cnfig.0         ; Start-bit for conversation with ADC (always 1).
SglDif      =       cnfig.1         ; 1=single-ended, 2-ch; 0=differential, 1-ch
OddSign     =       cnfig.2         ; Selects ch 0 or 1 for input or + polarity.
Msbf        =       cnfig.3         ; MSBF mode select (always 1).
Xmit        =       0               ; TRIS setting to send data to LTC1298.
Recv        =       100b            ; TRIS setting to receive data from LTC1298.
FixBs       =       1001b           ; Fixed bits for configuration setting.
OutClk      =       4               ; Number of bits sent to LTC1298.
InClk       =       13              ; Number of bits received from LTC1298.

; Remember to change device info when programming part.
            device  pic16c55,xt_osc,wdt_off,protect_off
            reset   Start

; Set starting point in program ROM to zero
            org     0
start       mov     lra, #xmit      ; Set TRIS ra to send configuration to ADC.
            mov     lrb,#0          ; Set TRIS rb and rc to output.
            mov     lrc,#0          ; Deselect LTC1298 for now.
            setb    CS

; Set up the configuration bits. A 1 in sglDif means a single-ended conversion;
; 0 meansdifferential. For single-ended measurements, oddSign selects the channel:
; 0 = channel 0; 1 = channel 1. For differential conversions, oddSign selects polarity: 1
; = channel 1 +, 0 = channel 0 +.

            setb    sglDif          ; Set for single-ended.
            clrb    oddSign         ; Sample channel 0.
```

PIC Program Listing (cont.)

```
; Call the ADC subroutine.

                call    convert
                mov     rb, ADresL      ; Put the bits of ADC result on rb and rc.
                mov     rb, ADresH
                jmp     $               ; Stop program: results in registers 9 and A.

; This is the subroutine that gets the conversion from the LTC1298. Upon
; entry, the configuration bits must be set up in the cnfig register.
; Upon exit, the 12-bit result will be in ADresH/L. The cnfig register
; will have been restored to its original state.

; This conversion routine will work properly at PIC clock speeds up to 8 MHz.
; Faster clocks will violate the LTC1298's max clock rate of 200 kHz. To slow
; the conversion routine, add more "jmp $+1" 2-cycle delays in :loop1 and
; :loop2.

Convert
                mov     lrb,#xmit       ; Ready to transmit configuration to ADC.
                clrb    CLK             ; Begin with clock low.
                clrb    CS
                OR      cnfig,#fixBs    ; Write 1s to start and msbf bits
                mov     clocks,#outClk  ; Set up number of config bits to write.
                clr     ADresL          ; Clear results registers.
                clr     ADresH
:loop1          rr      cnfig           ; Rotate bit 0 into carry.
                movb    DATA,c          ; Move carry bit to DATA pin.
                setb    CLK             ; Pulse the clock line.
                jmp     $+1
                clrb    CLK
                djnz    clocks,:loop1   ; Repeat for all config bits.
                rr      cnfig           ; Rearrange config register to original state.
                swap    cnfig
                mov     !rb,#recv       ; Change TRIS to input data.
                mov     clocks,#inClk   ; Set up number of data bits to receive.
:loop2          rl      ADresL          ; Rotate 16-bit ADres register left.
                rl      ADresH
                snb     DATA            ; Copy data bit to lsb of ADres.
                setb    ADresL.0
                sb      DATA
                clrb    ADresL.0
                setb    CLK             ; Pulse the clock line.
                jmp     $+1
                clrb    CLK
                djnz    clocks,:loop2   ; Repeat for all data bits.
                setb    CS              ; Deactivate the LTC1298.
                ret
```

BASIC Stamp I (BS1-IC) and BASIC Stamp Ver. D Program Listing

Program: LTC1298.BS1 (LTC1298 analog-to-digital converter)

The LTC1298 is a 12-bit, two-channel ADC. Its high resolution, low supply current, low cost, and built-in sample/hold feature make it a great companion for the Stamp in sensor and data-logging applications. With its 12-bit resolution, the LTC1298 can measure tiny changes in input voltage; 1.22 millivolts (5-volt reference/4096).

ADC Interface Pins

The 1298 uses a four-pin interface, consisting of chip-select, clock, data input, and data output. In this application, we tie the data lines together with a 1k resistor and connect the Stamp pin designated DIO to the data-in side of the resistor. The resistor limits the current flowing between DIO and the 1298's data out in case a programming error or other fault causes a "bus conflict." This happens when both pins are in output mode and in opposite states (1 vs 0). Without the resistor, such a conflict would cause large currents to flow between pins, possibly damaging the Stamp and/or ADC.

```
SYMBOL      CS = 0          Chip select; 0=active.
SYMBOL      CLK = 1         Clock to ADC; out on rising, in on falling edge.
SYMBOL      DIO_n = 2       Pin_number_of data input/output.
SYMBOL      DIO_p = pin2    Variable_name_of data input/output.
SYMBOL      ADbits = b1     Counter variable for serial bit reception.
SYMBOL      AD = w1         12-bit ADC conversion result.
```

ADC Setup Bits

The 1298 has two modes. As a single-ended ADC, it measures the voltage at one of its inputs with respect to ground. As a differential ADC, it measures the difference in voltage between the two inputs. The sglDif bit determines the mode; 1 = single-ended, 0 = differential. When the 1298 is single-ended, the oddSign bit selects the active input channel; 0 = channel 0 (pin 2), 1 = channel 1 (pin 3). When the 1298 is differential, the oddSign bit selects the polarity between the two inputs; 0 = channel 0 is +, 1 = channel 1 is +. The msbf bit determines whether clock cycles_after_the 12 data bits have been sent will send 0s (msbf = 1) or a least-significant-bit-first copy of the data (msbf = 0). This program doesn't continue clocking after the data has been obtained, so this bit doesn't matter.

You probably won't need to change the basic mode (single/differential) or the format of the post-data bits while the program is running, so these are assigned as constants. You probably will want to be able to change channels, so oddSign (the channel selector) is a bit variable.

BASIC Stamp I and Ver. D Program Listing (cont.)

```
SYMBOL      sglDif = 1              Single-ended, two-channel mode.
SYMBOL      msbf = 1                Output 0s after data transfer is complete.
SYMBOL      oddSign = bit0          Program writes channel # to this bit.
```

Demo Program

This program demonstrates the LTC1298 by alternately sampling the two input channels and presenting the results on the PC screen using Debug.

```
high CS                             Deactivate the ADC to begin.
Again:                              Main loop.
 For oddSign = 0 to 1               Toggle between input channels.
  gosub Convert                     Get data from ADC.
  debug "ch",#oddSign,":",#AD,cr    Show the data on PC screen.
  pause 500                         Wait a half second.
 next                                Change input channels.
goto Again                          Endless loop.
```

ADC Subroutine

Here's where the conversion occurs. The Stamp first sends the setup bits to the 1298, then clocks in one null bit (a dummy bit that always reads 0) followed by the conversion data.

```
Convert:
 low CLK                            Low clock-output on rising edge.
 high DIO_n                         Switch DIO to output high (start bit).
 low CS                              Activate the 1298.
 pulsout CLK,5                       Send start bit.
 let DIO_p = sglDif                  First setup bit.
 pulsout CLK,5                       Send bit.
 let DIO_p = oddSign                Second setup bit.
 pulsout CLK,5                       Send bit.
 let DIO_p = msbf                    Final setup bit.
 pulsout CLK,5                       Send bit.
 input DIO_n                        Get ready for input from DIO.
 let AD = 0                         Clear old ADC result.
 for ADbits = 1 to 13               Get null bit + 12 data bits.
  let AD = AD%r*%r2+DIO_p           Shift AD left, add new data bit.
  pulsout CLK,5                      Clock next data bit in.
 next                                Get next data bit.
 high CS                            Turn off the ADC
return                              Return to program.
```

BASIC Stamp II (BS2-IC) Program Listing

Program: LTC1298.BS2 (LTC 1298 analog-to-digital converter)

The LTC1298 is a 12-bit, two-channel ADC. Its high resolution, low supply current, low cost, and built-in sample/hold feature make it a great companion for the Stamp in sensor and data-logging applications. With its 12-bit resolution, the LTC1298 can measure tiny changes in input voltage; 1.22 millivolts (5-volt reference/4096).

ADC Interface Pins

The 1298 uses a four-pin interface, consisting of chip-select, clock, data input, and data output. In this application, we tie the data lines together with a 1k resistor and connect the Stamp pin designated DIO to the data-in side of the resistor. The resistor limits the current flowing between DIO and the 1298's data out in case a programming error or other fault causes a "bus conflict." This happens when both pins are in output mode and in opposite states (1 vs 0). Without the resistor, such a conflict would cause large currents to flow between pins, possibly damaging the Stamp and/or ADC.

```
CS    con       0          Chip select; 0 = active
CLK   con       1          Clock to ADC; out on rising, in on falling edge.
DIO_n           con        2          Data I/O pin_number_.
config          var        nib        Configuration bits for ADC.
AD    var       word       Variable to hold 12-bit AD result.
```

ADC Setup Bits

The 1298 has two modes. As a single-ended ADC, it measures the voltage at one of its inputs with respect to ground. As a differential ADC, it measures the difference in voltage between the two inputs.
The sgIDif bit determines the mode; 1 = single-ended, 0 = differential.
When the 1298 is single-ended, the oddSign bit selects the active input channel; 0 = channel 0 (pin 2), 1 = channel 1 (pin 3).
When the 1298 is differential, the oddSign bit selects the polarity between the two inputs; 0 = channel 0 is +, 1 = channel 1 is +.
The msbf bit determines whether clock cycles_after_the 12 data bits have been sent will sent 0s (msbf = 1) or a least-significant-bit-first copy of the data (msbf = 0). This program doesn't continue clocking after the data has been obtained, so this bit doesn't matter.

You probably won't need to change the basic mode (single/differential) or the format of the post-data bits while the program is running, so these are assigned as constants. You probably will want to be able to change channels, so oddSign (the channel selector) is a bit variable.

BASIC Stamp II Program Listing (cont.)

```
startBvar       config.bit0     Start bit for comm with ADC.
sglDif var      config.bit1     Single-ended or differential mode.
oddSign         var             config.bit2     Channel selection.
msbf var        config.bit3     Output 0s after data xfer complete.
```

Demo Program

This program demonstrates the LTC1298 by alternately sampling the two input channels and presenting the results on the PC screen using Debug.

```
high CS                         Deactivate ADC to begin.
high DIO_n                      Set data pin for first start bit.
again:                          Main loop.
 for oddSign = 0 to 1           Toggle between input channels.
   gosub convert                Get data from ADC.
   debug "channel",DEC odd      Sign, ":",DEC AD,cr' Display data.
   pause 500                    Wait a half second.
  next                          Change channels.
goto again                      Endless loop.
```

ADC Subroutine

Here's where the conversion occurs. The Stamp first sends the config bits to the 1298, then clocks in the conversion data. Note the use of the new BS2 instructions Shiftout and Shiftin. Their use is pretty straightforward here: Shiftout sends data bits to pin DIO and clock the CLK pin. Sending the least-significant bit first, it shifts out the four bits of the variable config. Then Shiftin changes DIO to input and clocks in the data bits--most-significant bit first, post clock (valid after clock pulse). It shifts in 12 bits to the variable AD.

```
convert:
 config = config 1 %1011       Set all bits except oddSign.
 low CS                         Activate the ADC.
 shiftout DIO_n,CLK,lsbfirst,   [config\4]      Send config bits.
 shiftin DIO_n,CLK,msbpost      [AD\12]         Get data bits.
 high CS                        Deactivate the ADC.
return                          Return to program.
```

LINEAR TECHNOLOGY

LTC1286/LTC1298

Micropower Sampling 12-Bit A/D Converters In S0-8 Packages

FEATURES

- **12-Bit Resolution**
- **8-Pin SOIC Plastic Package**
- **Low Cost**
- **Low Supply Current: 250ìA Typ.**
- Auto Shutdown to 1nA Typ.
- Guaranteed ±3/4LSB Max DNL
- Single Supply 5V to 9V Operation
- On-Chip Sample-and-Hold
  60ìs Conversion Time
- Sampling Rates:
  - 12.5 ksps (LTC1286)
  - 11.1 ksps (LTC1298)
- I/O Compatible with SPI, Microwire, etc.
- Differential Inputs (LTC1286)
- 2-Channel MUX (LTC1298)
- 3V Versions Available: LTC1285/LTC1288

APPLICATIONS

- Battery-Operated Systems
- Remote Data Acquisition
- Battery Monitoring
- Handheld Terminal Interface
- Temperature Measurement
- Isolated Data Acquisition

DESCRIPTION

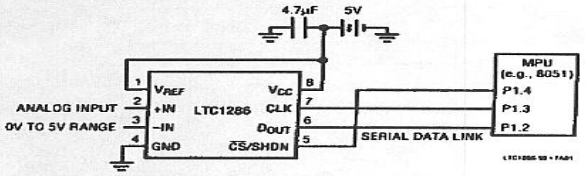
The LTC1286/LTC1298 are micropower, 12-bit, successive approximation sampling A/D converters. They typically draw only 250 A of supply current when converting and automatically power down to a typical supply current of 1nA whenever they are not performing conversions. They are packaged in 8-pin SO packages and operate on 5V to 9V supplies. These 12-bit, switched-capacitor, successive approximation ADCs include sample-and-holds. The LTC1286 has a single differential analog input. The LTC1298 offers a software selectable 2-channel MUX.

On-chip serial ports allow efficient data transfer to a wide range of microprocessors and microcontrollers over three wires. This, coupled with micropower consumption, makes remote location possible and facilitates transmitting data through isolation barriers.

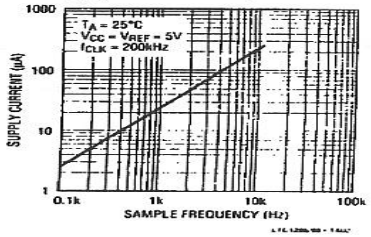
These circuits can be used in ratiometric applications or with an external reference. The high impedance analog inputs and the ability to operate with reduced spans (to 1.5V full scale) allow direct connection to sensors and transducers in many applications, eliminating the need for gain stages.

TYPICAL APPLICATIONS

25µW, S0-8 Package, 12-Bit ADC Samples at 200Hz and Runs Off a 5V Supply



Supply Current vs Sample Rate



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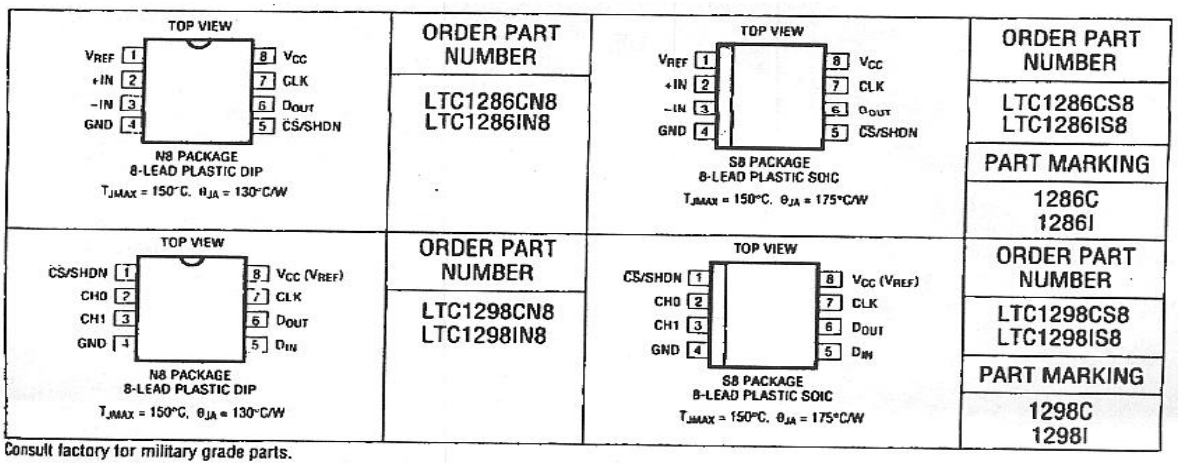
LINEAR TECHNOLOGY

ABSOLUTE MAXIMUM RATINGS (Notes 1 and 2)

Supply Voltage (V_{CC}) to GND	12V	Power Dissipation	500mW
Voltage		Operating Temperature Range	
Analog and Reference	-0.3V to V_{CC} + 0.3V	LTC1286C/LTC1298C	0°C to 70°C
Digital Inputs	-0.3V to 12V	LTC1286I/LTC1298I	-40°C to 85°C
Digital Output	-0.3V to V_{CC} + 0.3V	Storage Temperature Range	-65°C to 150°C
		Lead Temperature (Soldering, 10 sec)	300°C

PACKAGE/ORDER INFORMATION



Consult factory for military grade parts.

RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{CC}	Supply Voltage (Note 3)	LTC1286	4.5		9.0	V
		LTC1298	4.5		5.5	V
t_{CLK}	Clock Frequency	V_{CC} = 5V	(Note 4)		200	kHz
t_{CYC}	Total Cycle Time	LTC1286, t_{CLK} = 200kHz	80			ìs
		LTC1298, t_{CLK} = 200kHz	90			ìs
??	Hold Time, D_{IN} After CLK	V_{CC} = 5V	150			ns
t_{suCS}	Setup Time CS Before First CLK (See Operating Sequence)	LTC1286, V_{CC} = 5V	2			ìs
		LTC1298, V_{CC} = 5V	2			ìs
t_{suDI}	Setup Time, D_{IN} Stable Before CLK	V_{CC} = 5V	400			ns
t_{WHCLK}	CLK High Time	V_{CC} = 5V	2			ìs
t_{WLCLK}	CLK Low Time	V_{CC} = 5V	2			ìs
t_{WHCS}	CS High Time Between Data Transfer Cycles	V_{CC} = 5V	2			ìs
t_{WLCS}	CS Low Time During Data Transfer	LTC1286, t_{CLK} = 200kHz	75			ìs
		LTC1298, t_{CLK} = 200kHz	85			ìs

CONVERTER AND MULTIPLEXER CHARACTERISTICS (Note 5)

			LTC1286			LTC1298			
PARAMETER	**CONDITIONS**		**MIN**	**TYP**	**MAX**	**MIN**	**TYP**	**MAX**	**UNIT**
Resolution (No Missing Codes)		•	12			12			Bits
Integral Linearity Error	(Note 6)	•		±3/4	±2		±3/4	±2	LSB
Differential Linearity Error		•		±1/4	±3/4		±1/4	±3/4	LSB
Offsel Error		•		¾	±3		3/4	±3	LSB
Gain Error		•		±2	±8		±2	±8	LSB
Analog Input Range	(Note 7 and 8)	•		=0.05V to V_{CC} + 0.05V					V
REF Input Range (LTC1286)	4.5 ≤ V_{CC} ≤ 5.5V			1.5V to V_{CC} + 0.05V					V
(Notes 7, 8, and 9)	5.5V ≤ V_{CC} ≤ 9V			1.5V to 5.55V					V
Analog Input Leakage Current (Note 10)		•			±1			±1	IA

DIGITAL AND DC ELECTRICAL CHARACTERISTICS (Note 5)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{IH}	High Level Input Voltage	V_{CC} = 5.25V	•	2			V
V_{IL}	Low Level Input Voltage	V_{CC} = 4.75V	•			0.8	V
I_{IH}	High Level Input Current	V_{IN} = V_{CC}	•			2.5	ÌA
I_{IL}	Low Level Input Current	V_{IN} = 0V	•			-2.5	ÌA
V_{OH}	High Level Output Voltage	V_{CC} = 4.75V, I_O = 10ìA	•	4.0	4.64		V
		V_{CC} = 4.75V, I_O = 360ìA	•	2.4	4.62		V
V_{OL}	Low Level Output Voltage	V_{CC} = 4.75V, I_O = 1.6mA	•			0.4	V
I_{OZ}	HI-Z Output Leakage	CS = High	•			±3	ÌA
I_{SOURCE}	Output Source Current	V_{OUT} = 0V			-25		MA
I_{SINK}	Output Sink Current	V_{OUT} = V_{CC}			45		MA
R_{REF}	Reference Input Resistance	CS = V_{CC}			5000		MU
	(LTC1286)	CS = GND			55		KÙ
I_{REF}	Reference Current (LTC1286)	CS = V_{CC}	•		0.001	2.5	ÌA
		t_{CYC} ≥ 640iS, f_{CLK} ≤ 25kHz	•		90	140	ÌA
		t_{CYC} = 80iS, f_{CLK} = 200kHz	•		90	140	ÌA
I_{CC}	Supply Current	CS = V_{CC}	•		0.001	±3.0	ÌA
		LTC1286, t_{CYC} ≥ 640iS, f_{CLK} ≤ 25kHz	•		200	400	ÌA
		LTC1286, t_{CYC} = 80iS, f_{CLK} = 200kHz	•		250	500	ÌA
		LTC1298, t_{CYC} ≥ 720iS, f_{CLK} ≤ 25kHz	•		290	490	ÌA
		LTC1298, t_{CYC} = 90iS, f_{CLK} = 200kHz	•		340	640	ÌA

DYNAMIC ACCURACY f_{SMPL} = 12.5kHz (LTC1286), f_{SMPL} = 11.1kHz (LTC1298) (Note 5)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
S/(N+D)	Signal-to-Noise Plus Distortion Ratio	1kHz/7kHz Input Signal		71/68		DB
THD	Total Harmonic Distortion (Up to 5th Harmonic)	1kHz/7kHz Input Signal		-84/-80		DB
SFDR	Spurious-Free Dynamic Range	1kHz/7kHz Input Signal		90/86		DB
	Peak Harmonic or Spurious Noise	1kHz/7kHz Input Signal		-90/-86		DB

PARALLAX INC.
sales / technical support (916) 624-8333 • fax (916) 624-8003
pictech@parallainc.com • stamptech@parallaxinc.com

AC CHARACTERISTICS (Note 5)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
t_{SMPL}	Analog Input Sample Time	See Operating Sequence			1.5		CLK Cycles
f_{SMPL}(MAX)	Maximum Sampling Frequency	LTC1286	•	12.5			KHz
		LTC1298	•	11.1			KHz
t_{CONV}	Conversion Time	See Operating Sequence			12		CLK Cycles
t_{dDO}	Delay Time, CLK to D_{OUT} Data Valid	See Test Circuits	•		250	600	Ns
t_{dis}	Delay Time, CS to D_{OUT} Hi-Z	See Test Circuits	•		135	300	Ns
f_{en}	Delay Time, CLK to D_{OUT} Enable	See Test Circuits	•		75	200	Ns
t_{hDO}	Time Output Data Remains Valid After CLK	C_{LOAD} = 100pF			230		Ns
??	D_{OUT} Fall Time	See Test Circuits	•		20	75	Ns
??	D_{OUT} Rise Time	See Test Circuits	•		20	75	Ns
??	Input Capacitance	Analog Inputs, On Channel			20		PF
		Analog Inputs, Off Channel			5		PF
		Digital Input			5		PF

The • denotes specifications which apply over the full operating temperature range.

Note 1: Absolute maximum ratings are those values beyond which the life of a device may be impaired.

Note 2: All voltage values are with respect to GND.

Note 3: These devices are specified at 5V. For 3V specified devices, see LTC1285 and LTC1288.

Note 4: Increased leakage currents at elevated temperatures cause the S/H to droop, therefore it is recommended that $t_{CLK} \geq 120kHz$ at 85°C, $f_{CLK} \geq 75kHz$ at 70° and $t_{CLK} \geq 1kHz$ at 25°C.

Note 5: V_{CC} = 5V, V_{REF} = 5V and CLK = 200kHz unless otherwise specified.

Note 6: Linearity error is specified between the actual end points of the A/D transfer curve.

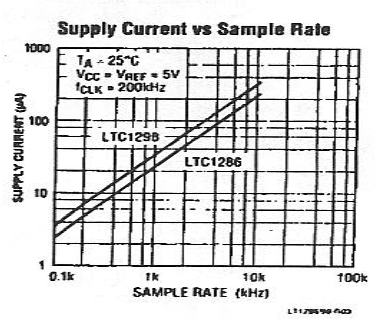
Note 7: Two on-chip diodes are fied to each reference and analog input which will conduct for reference or analog input voltages one diode drop below GND or one diode drop above V_{CC}. This spec allows 50mV forward bias of either diode for $4.5V \leq V_{CC} \leq 5.5V$. This means that as long as the reference or analog input does not exceed the supply voltage by more than 50mV the output code will be correct. To achieve an absolute 0V to 5V input voltage range will therefore require a minimum supply voltage of 4.950V over initial tolerance, temperature variations and loading. For $5.5V < V_{CC} \leq 9V$, reference and analog input range cannot exceed 5.55V. If reference and analog input range are greater than 5.55V, the output code will not be guaranteed to be correct.

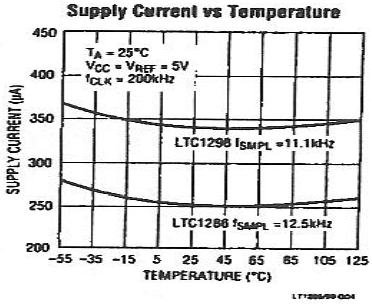
Note 8: The supply voltage range for the LTC1286 is from 4.5V to 9V, but the supply voltage range for the LTC1298 is only from 4.5V to 5.5V.

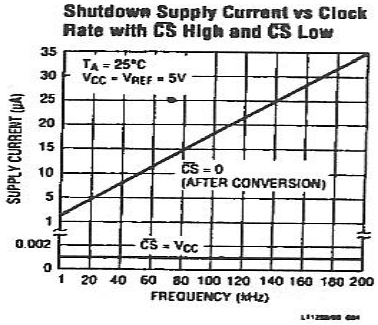
Note 9: Recommended operating conditions

Note 10: Channel leakage current is measured after the channel.

TYPICAL PERFORMANCE CHARACTERISTICS

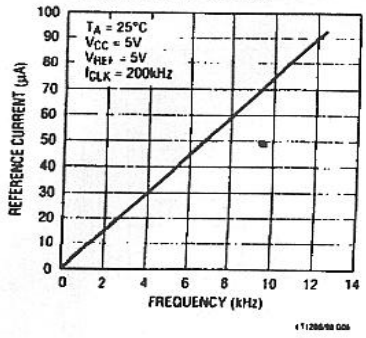




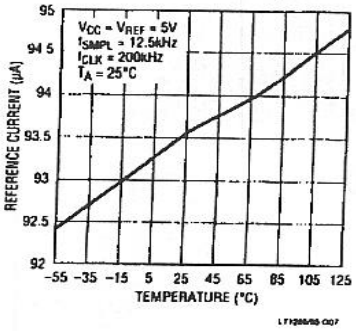


TYPICAL PERFORMANCE CHARACTERISTICS

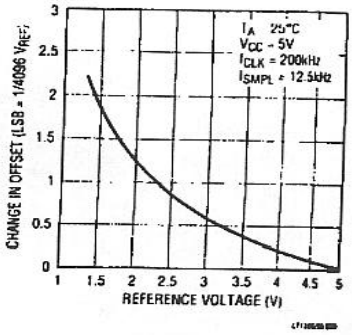
Reference Current vs Sample Rate (LTC1286)



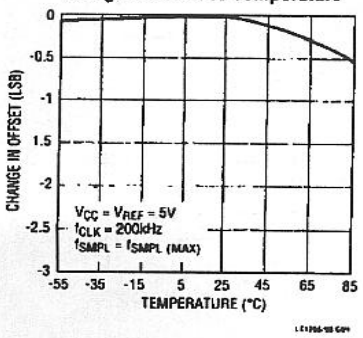
Reference Current vs Temperature



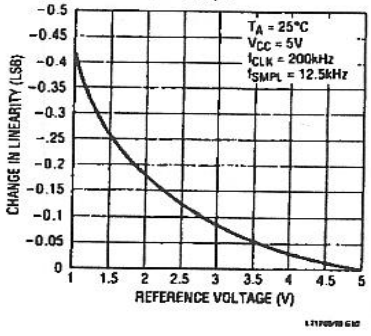
Change in Offset vs Reference Voltage



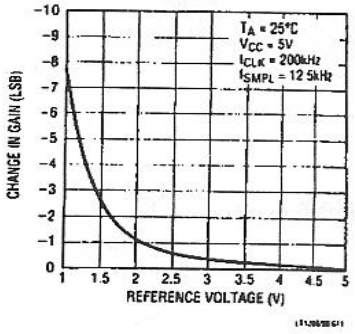
Change in Offset vs Temperature



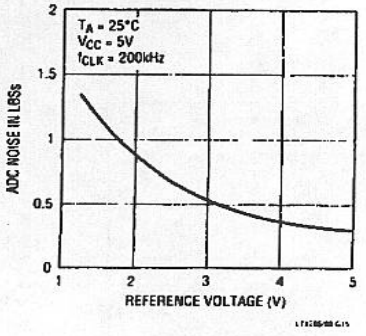
Change In Linearity vs Reference Voltage



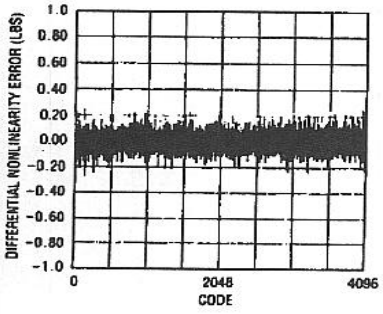
Change In Gain vs Reference Voltage



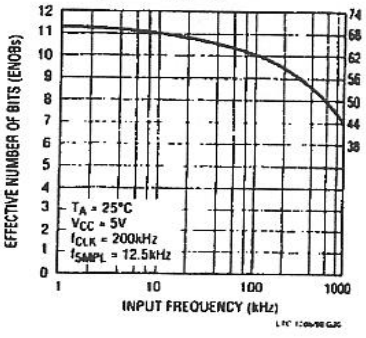
Peak-to-Peak ADC Noise vs Reference Voltage



Differential Nonlinearity vs Code



Effective Bits and S/(N + D) vs Input Frequency



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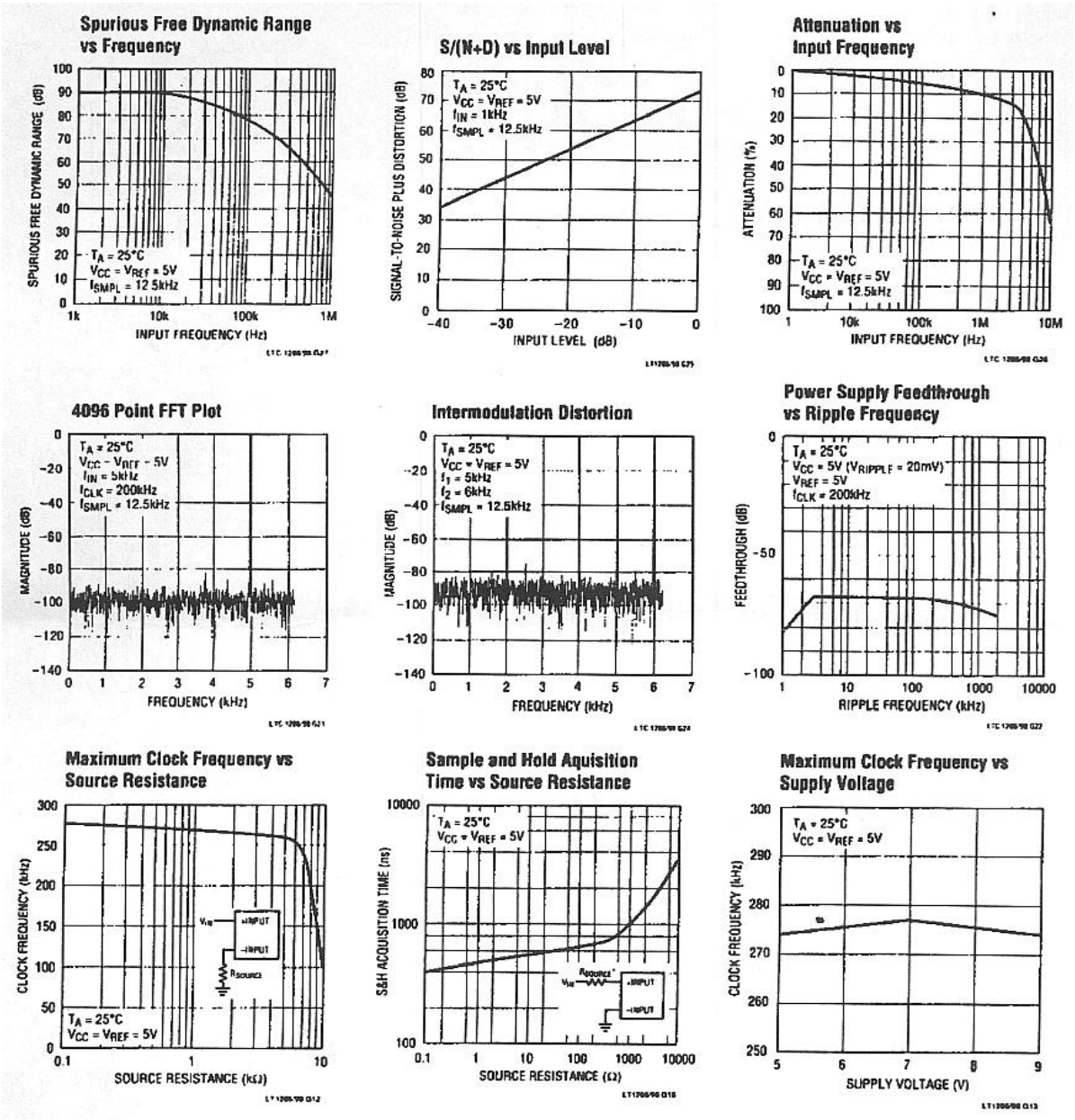
TYPICAL PERFORMANCE CHARACTERISTICS



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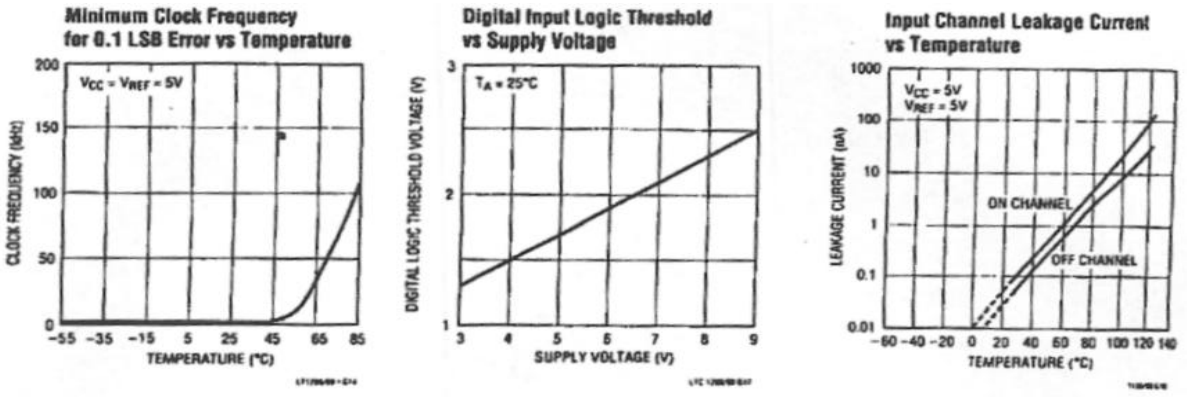
TYPICAL PERFORMANCE CHARACTERISTICS



PIN FUNCTIONS

LTC1286

VREF (Pin 1): Reference Input. The reference input defines the span of the A/D converter.

IN+ (Pin 2): Positive Analog Input.

IN- (Pin 3): Negative Analog Input.

GND (Pin 4): Analog Ground. GND should be tied directly to an analog ground plane.

CS/SHDN (Pin 5): Chip Select Input. A logic low on this input enables the LTC1286. A logic high on this input disables and powers down the LTC1286.

D_{OUT} (Pin 6): Digital Data Output. The A/D conversion result is shifted out of this output.

CLK(Pin 7): Shift Clock. This clock synchronizes the serial data transfer and determines conversion speed.

V_{CC} (Pin 8): Power Supply Voltage. This pin provides power to the A/D converter. It must be kept free of noise and ripple by bypassing directly to the analog ground plane.

LTC1298

CS/SHDN (Pin 1): Chip Select Input. A logic low on this input enables the LTC1298. A logic high on this input disables and powers down the LTC1298.

CHO (Pin 2): Analog Input.

CH1 (Pin 3): Analog Input.

GND (Pin 4): Analog Ground. GND should be tied directly to an analog ground plane.

D_{IN} (Pin 5): Digital Data Input. The multiplexer address is shifted into this input.

D_{OUT} (Pin 6): Digital Data Output. The A/D conversion result is shifted out of this output.

CLK (Pin 7): Shift Clock. This clock synchronizes the serial data transfer and determines conversion speed.

V_{CC}/V_{REF} (Pin 8): Power Supply and Reference Voltage. This pin provides power and defines the span of the A/D converter. It must be kept free of noise and ripple by bypassing directly to the analog ground plane.

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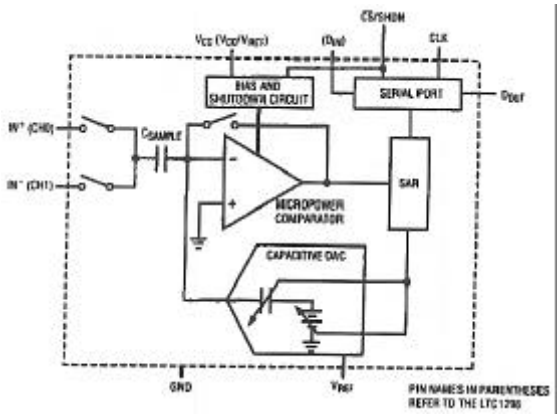
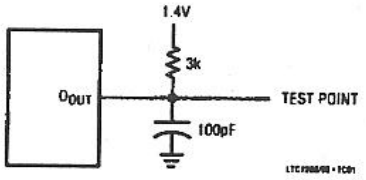
BLOCK DIAGRAM



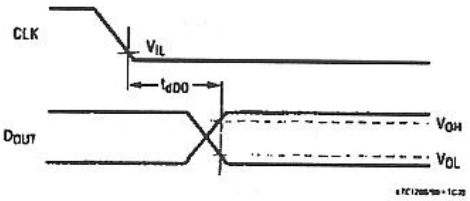
TEST CIRCUITS

Load Circuit for t_{dDO}, t_r and t_f

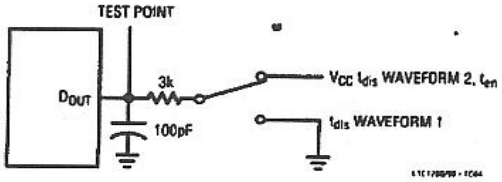


Voltage Waveforms for D_{OUT} Rise and Fall Times, t_r, t_f

Voltage Waveforms for D_{OUT} Delay Times, t_{dDO}



Load Circuit for t_{dis} and t_{en}



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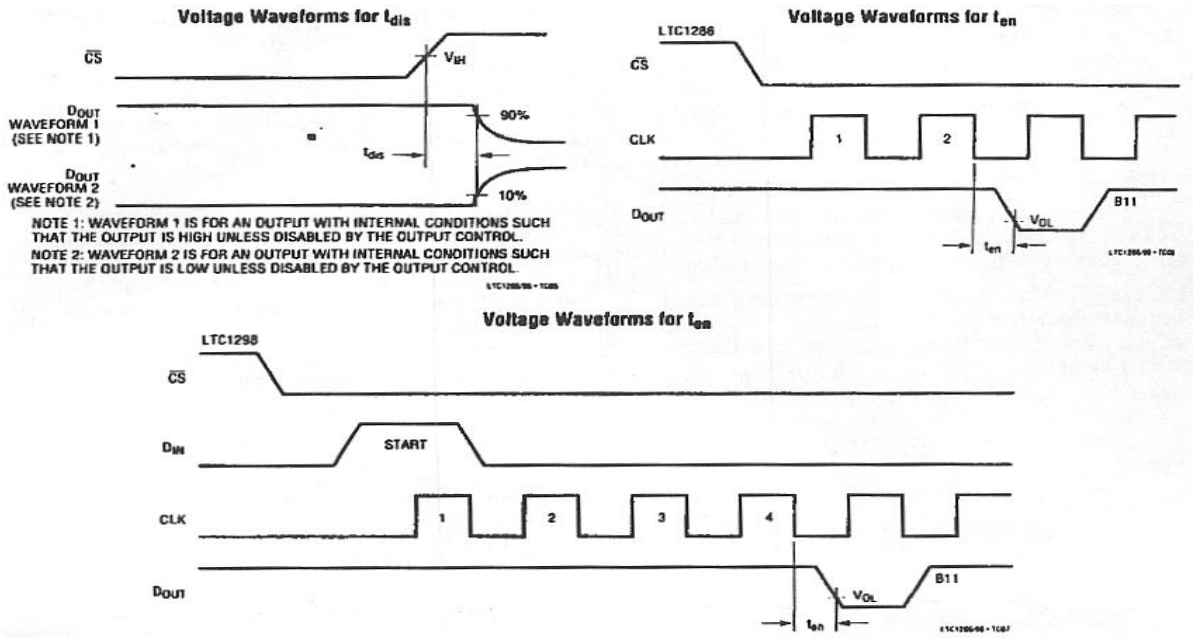
TEST CIRCUITS



APPLICATION INFORMATION

OVERVIEW

The LTC1286 and LTC1298 are micropower, 12-bit, successive approximation sampling A/D converters. The LTC1286 typically draws 250 A of supply current when sampling at 12.5kHz while the LTC1298 nominally consumes 350 A of supply current when sampling at 11.1 kHz. The extra 100 A of supply current on the LTC1298 comes from the reference input which is intentionally tied to the supply. Supply current drops linearly as the sample rate is reduced (see Supply Current vs Sample Rate). The ADCs automatically power down when not performing conversions, drawing only leakage current. They are packaged in 8-pin SO and DIP packages. The LTC1286 operates on a single supply from 4.5V to 9V, while the LTC1298 operates from a 4.5V to 5.5V supply.

Both the LTC1286 and the LTC1298 contain a 12-bit, switched-capacitor ADC, a sample-and-hold, and a serial port (see Block Diagram). Although they share the same basic design, the LTC1286 and LTC1298 differ in some respects. The LTC1286 has a differential input and has an external reference input pin. It can measure signals floating on a DC common-mode voltage and can operate with reduced spans to 1V. Reducing the spans allows it to achieve 244 V resolution. The LTC1298 has a two -channel input multiplexer and can convert either channel with respect to ground or the difference between the two. The reference input is tied to the supply pin.

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APPLICATION INFORMATION

SERIAL INTERFACE

The 2-channel LTC1298 communicates with microprocessors and other external circuitry via a synchronous, half duplex, 4-wire serial interface. The single channel LTC1286 uses a 3-wire interface (see Operating Sequence in Figures 1 and 2).

Data Transfer

The CLK synchronizes the data transfer with each bit being transmitted on the falling CLK edge and captured on the rising CLK edge in both transmitting and receiving systems.

The LTC1286 does not require a configuration input word and has no D_{IN} pin. A falling CS initiates data transfer as shown in the LTC1286 operating sequence. After CS falls the second CLK pulse enables D_{OUT}. After one null bit the A/D conversion result is output on the D_{OUT} line. Bringing CS high resets the LTC1286 for the next data exchange.

The LTC1298 first receives input data and then transmits back the A/D conversion result (half duplex). Because of the half duplex operation, D_{IN} and D_{OUT} may be tied together allowing transmission over just 3 wires: CS, CLK and DATA (D_{IN}/D_{OUT}).

Data transfer is initiated by a falling chip select (CS) signal. After CS falls the LTC1298 looks for a start bit. After the start bit is received, the 3-bit input word is shifted into the D_{IN} input which configures the LTC1298 and starts the conversion. After one null bit, the result of the conversion is output on the D_{OUT} line. At the end of the data exchange CS should be brought high. This resets the LTC1298 in preparation for the next data exchange.

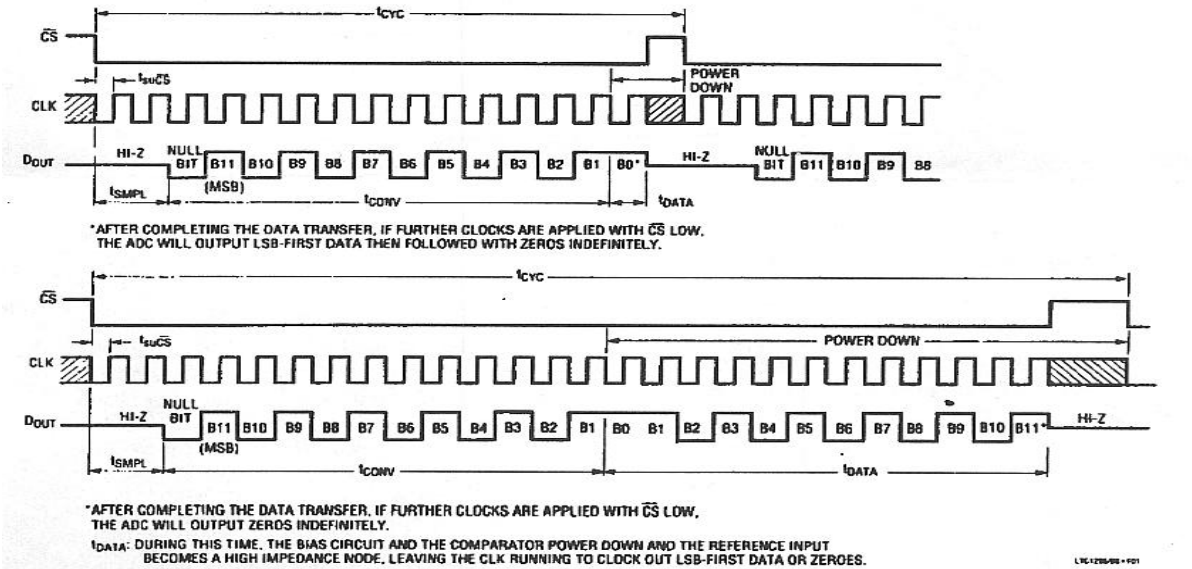
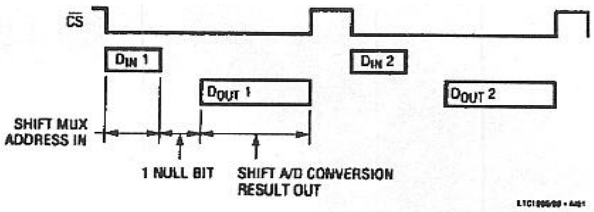
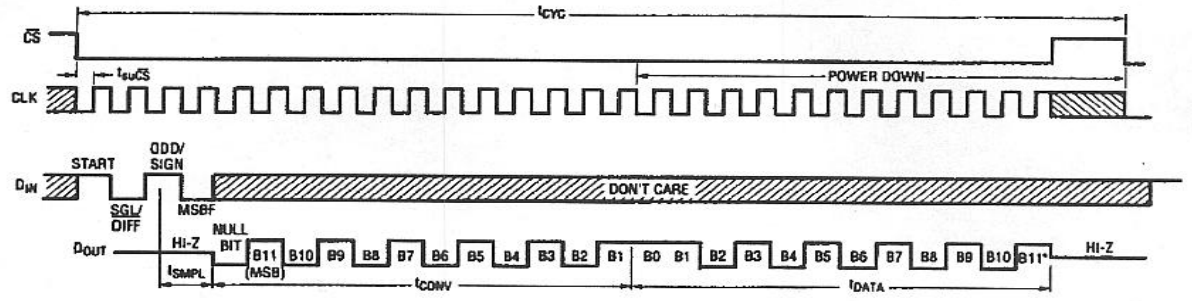


Figure 1. LTC1286 Operating Sequence

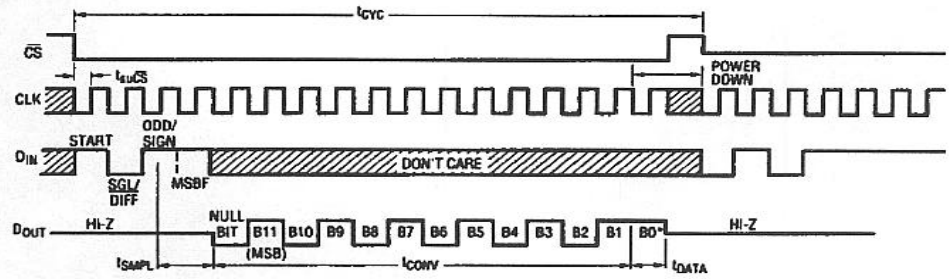
APPLICATION INFORMATION



MSB-First Data (MSBF = 0)



MSB-First Data (MSBF = 1)



*AFTER COMPLETING THE DATA TRANSFER, IF FURTHER CLOCKS ARE APPLIED WITH $\overline{CS}$ LOW, THE ADC WILL OUTPUT ZEROS INDEFINITELY.

t_{DATA}: DURING THIS TIME, THE BIAS CIRCUIT AND THE COMPARATOR POWER DOWN AND THE REFERENCE INPUT BECOMES A HIGH IMPEDANCE NODE, LEAVING THE CLK RUNNING TO CLOCK OUT LSB-FIRST DATA OR ZEROES.

Figure 2. LTC1298 Operating Sequence Example: Differential Inputs (CH+, CH−)

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